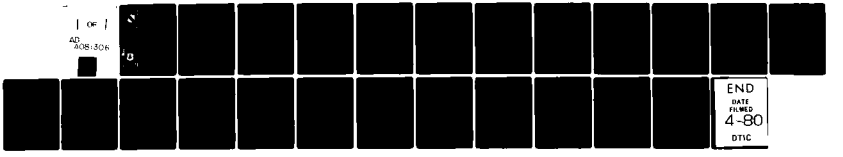
AD-A081 306 FRANK J SEILER RESEARCH LAB UNITED STATES AIR FORCE A--ETC F/G 5/3
USE OF THE BOX-JENKINS APPROACH FOR PRELIMINARY FOREIGN EXCHANG--ETC(U)
JAN 80 J S BRUSH, J H GRADY
UNCLASSIFIED FJSRL-TR-80-0003 NL



FRANK J. SEILER RESEARCH LABORATORY

SRL-TR-80-0003 JANUARY 1980

USE OF THE BOX-JENKINS APPROACH FOR PRELIMINARY FOREIGN EXCHANGE RATE DATA ANALYSIS

FINAL REPORT

LT COL JOHN S. BRUSH
2LT JAMES H. GRADY

PROJECT 2304

AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

FJSRL-TR-80-0003

This document was prepared by the Applied Mathematics Division, Directorate of Aerospace-Mechanics Sciences, Frank J. Seiler Research Laboratory, United States Air Force Academy, Colorado. The research was conducted under Project Work Unit Number 2304-F1-64, The Development and Extension of Inflation Forecasting Models for Specific DOD Inflation Measures. Lt Col J. S. Brush was the Project Engineer in charge of the work.

When U.S. Government drawings, specifications or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished or in any way supplied the said drawings, specifications or other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

Inquiries concerning the technical content of this document should be addressed to the Frank J. Seiler Research Laboratory (AFSC), FJSRL/NH, USAF Academy, Colorado 80840. Phone AC 303-472-3122.

This report has been reviewed by the Chief Scientist and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

JOHN S. BRUSH, Lt Col, USAF
Project Engineer

JOSEPH S. FORD II, Lt Col, USAF
Director
Aerospace-Mechanics Sciences

WILLIAM D. SIURU, JR., Lt Col, USAF
Commander

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

Printed in the United States of America. Qualified requestors may obtain additional copies from the Defense Documentation Center. All others should apply to: National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: SRL-TR-80-0003	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: USE OF THE BOX-JENKINS APPROACH FOR PRELIMINARY FOREIGN EXCHANGE RATE DATA ANALYSIS	5. TYPE OF REPORT & PERIOD COVERED: Final rept. 1 Jan 1979 — 15 Jan 1980
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Lt Col John S. Brush; 2Lt James H. Grady	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Frank J. Seiler Research Lab (AFSC), USAF Academy, Colorado 80840	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: DRS 61102F; 2304-F1-64
11. CONTROLLING OFFICE NAME AND ADDRESS: Frank J. Seiler Research Lab (AFSC), USAF Academy, Colorado 80840	12. REPORT DATE: January 1980 13. NUMBER OF PAGES: 21
14. MONITORING AGENCY NAME & ADDRESS *(If different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED 15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Time Series
Exchange Rates

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

An investigation using Box-Jenkins techniques into the stochastic structure of exchange rates of four European currencies with respect to the U.S. dollar reveals a common and apparently heretofore unreported six month periodicity.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

USE OF THE BOX-JENKINS APPROACH FOR PRELIMINARY FOREIGN EXCHANGE RATE DATA ANALYSIS

A

OVERVIEW

The following report concerns a preliminary study with some interesting results in the use of the 'BOX-JENKINS' approach contained in the 'SYBIL-RUNNER' FORECASTING PACKAGE and its application to foreign exchange rate data. Addressed in this study is a general description of the 'BOX-JENKINS' approach, its subsequent application to foreign exchange rate data, and a brief conclusion. The appendix provides tables and graphs for each of the four European countries considered.

DESCRIPTION OF 'BOX-JENKINS' APPROACH

GENERAL PROGRAM FLOW

The control program 'SYBIL' performs preliminary statistical analysis on data provided by the user. Along with the results of this analysis, 'SYBIL' prints a recommended list of time-series forecasting methods which may be suitable for use on the given data.

The second control routine, 'RUNNER', generates forecasts based on summary statistics and gives a listing of available methods. These twenty or more forecasting techniques are contained on over one dozen program segments using chaining or overlay techniques. Once in a selected forecasting routine, the user may be asked to supply more local parametric information required by a specific technique (e.g., alpha weight, seasonal period, short term differences, etc.). More specific information as to what each program can accomplish is contained in the interactive forecasting manual which accompanies 'SYBIL-RUNNER'.

After the completion of the desired program(s), control is then returned to 'RUNNER'. When done, the results file is read back in to 'RUNNER' and listed in a series of tables. The user can review the

summarized material and decide on additional steps.

After running the 'SYBIL-RUNNER' combination, the user will have completed:

1. A general analysis of his data
2. A screening of available forecasting techniques
3. A detailed examination of a few of the most appropria e techniques
4. Final selection of a technique

BOX-JENKINS METHOD

Of the available programs, the 'BOX-JENKINS' approach is a procedure for using autoregressive and/or moving average schemes for forecasting applications. This method identifies the Auto-Regressive, Moving-Average model that best fits as set of data.

There are, however, two points which must be considered when assessing the validity of this method.

1. The 'BOX-JENKINS' approach used in this program is a single variable model and cannot consider additional variables.

2. Because no information on the significance of model coefficient estimates is provided, aggregated fitted error comparisons between models are the only criteria on which model adequacy can be based.

APPLICATION OF 'BOX-JENKINS' TO EXCHANGE RATE DATA

USE OF 'RUNNER'

The first step after accessing 'SYBIL-RUNNER' is to execute 'RUNNER'. At this stage exchange rate data was read from a data file. After identifying the seasonality and any other necessary parameters, 'RUNNER' provides a list of summary statistics. For our investigation of Exchange Rates with respect to the U.S. dollar for Belgium, Denmark, Netherlands, and Norway, we used the 'BOX-JENKINS' method of forecasting.

USE OF 'BOX-JENKINS'

The three critical concerns for this program are: seasonality, order of differencing, and the choice of models.

1. Seasonality: The seasonality for each country is determined individually by the time lag present in the graph of the autocorrelation coefficients. The length of seasonality corresponds to the time lag of the highest autocorrelation coefficient. In the case of Belgium, Denmark, and Norway, a seasonal period of six (6) was apparent while Netherlands showed a seasonal period of five (5).

2. Order of Differencing: Before any model can be applied, the data must be stationary. In the case of all four European countries, the data was stationary at the first difference. The input for short term differencing (period to period) was one (1) while the input for long term differencing (level of seasonal periods apart) was zero (0).

3. Choice of Model: Based upon the auto and partial correlation coefficients and tests of alternate forms, the best model for all countries was:

$$(1 - WB)Y_t = (1 - \theta_s^* B^S)\, e_t$$

This model is auto-regressive (1) seasonal in moving-average.

After specifying the necessary parameters, 'BOX-JENKINS' provides a graph of the Residual Autocorrelation Coefficients complete with Standard Error, Chi Squared, and Degrees of Freedom. These residuals show the 'fit' of the model. Following the residuals a table of Actual Values vs. Predicted Values is provided. The final portion of the program allows the user to select the number of forecast periods. 'BOX-JENKINS' prints the desired number of predictions.

RETURN TO 'RUNNER'

Once the user has completed the 'BOX-JENKINS' program, the 'SYBIL-RUNNER' chain program returns him to 'RUNNER' for a comparison of results. Forecasting accuracy of 'BOX-JENKINS' is compared to "NAIVE 1' and 'NAIVE 2'. A table of best forecast and corresponding method is provided followed

by an opportunity to combine any of the techniques.

See the Appendices for monthly (Jan 1972 - Sep 1979) data, tables, models, and graphs for the four European countries studied.

CONCLUSION

Consideration of the results indicate an interesting point. All four countries exhibit a roughly six month autoregressive structure. Whether this structure is due to some overt action on the part of governments or to some inherent property of exchange rates is an interesting and open question. Whether this structure will persist in time is also a question of economic interest. We performed some tests on two subperiods and found the same structure in each period. This study should be considered as a preliminary report outlining the specific methodology to be taken to duplicate the results and serve as the basis for further research.

APPENDIX A - DATA

Monthly average exchange rates with respect to the U.S. dollar

Month	Belgium	Denmark	Netherlands	Norway
1.72	44.4	7.0	3.2	6.7
2.72	43.8	7.0	3.2	6.7
3.72	43.9	7.0	3.2	6.6
4.72	44.1	7.0	3.2	6.6
5.72	44.0	7.0	3.2	6.6
6.72	43.9	7.0	3.2	6.5
7.72	43.8	7.0	3.2	6.5
8.72	43.9	6.9	3.2	6.5
9.72	44.0	6.9	3.2	6.6
10.72	44.2	6.9	3.2	6.6
11.72	44.1	6.9	3.2	6.6
12.72	44.1	6.9	3.2	6.6
1.73	44.1	6.9	3.2	6.6
2.73	41.7	6.5	3.0	6.2
3.73	39.7	6.2	2.9	5.9
4.73	40.0	6.2	2.9	5.9
5.73	39.4	6.2	2.9	5.8
6.73	37.5	5.8	2.7	5.5
7.73	35.5	5.5	2.6	5.3
8.73	37.0	5.7	2.7	5.5
9.73	36.9	5.7	2.6	5.5
10.73	36.6	5.6	2.5	5.5
11.73	38.7	6.0	2.7	5.6
12.73	40.0	6.2	2.8	5.7
1.74	42.8	6.7	2.9	6.0
2.74	41.0	6.4	2.8	5.8
3.74	40.0	6.2	2.8	5.7
4.74	39.0	6.1	2.7	5.5
5.74	37.7	5.9	2.6	5.3
6.74	37.9	6.0	2.6	5.4
7.74	37.9	5.9	2.6	5.4
8.74	38.7	6.0	2.7	5.5
9.74	39.4	6.2	2.7	5.6
10.74	38.6	6.0	2.7	5.5
11.74	37.7	5.9	2.6	5.5
12.74	36.9	5.8	2.5	5.3
1.75	35.4	5.6	2.5	5.1
2.75	34.8	5.6	2.4	5.0
3.75	34.4	5.4	2.4	4.9
4.75	35.2	5.5	2.4	5.0
5.75	34.9	5.5	2.5	5.0
6.75	34.9	5.4	2.4	4.9
7.75	36.8	5.7	2.6	5.2
8.75	38.3	6.0	2.6	5.5
9.75	39.2	6.1	2.7	5.6
10.75	38.9	6.0	2.7	5.5
11.75	39.0	6.0	2.7	5.5
12.75	39.5	6.2	2.7	5.6

Month	Belgium	Denmark	Netherlands	Norway
1.76	39.3	6.2	2.7	5.6
2.76	39.1	6.1	2.7	5.5
3.76	39.2	6.1	2.7	5.5
4.76	39.0	6.0	2.7	5.5
5.76	39.2	6.1	2.7	5.5
6.76	39.6	6.1	2.7	5.5
7.76	39.7	6.2	2.7	5.6
8.76	39.0	6.1	2.7	5.5
9.76	38.4	6.0	2.6	5.4
10.76	37.3	5.9	2.5	5.3
11.76	37.0	5.9	2.5	5.3
12.76	36.4	5.8	2.5	5.2
1.77	36.7	5.9	2.5	5.3
2.77	36.9	5.9	2.5	5.3
3.77	36.7	5.9	2.5	5.3
4.77	36.3	6.0	2.5	5.3
5.77	36.1	6.0	2.5	5.3
6.77	36.1	6.0	2.5	5.3
7.77	35.5	6.0	2.4	5.3
8.77	35.6	6.0	2.4	5.3
9.77	35.8	6.2	2.5	5.5
10.77	35.4	6.1	2.4	5.5
11.77	35.2	6.1	2.4	5.5
12.77	33.8	5.9	2.3	5.2
1.78	32.8	5.8	2.3	5.1
2.78	32.3	5.7	2.2	5.3
3.78	31.7	5.6	2.2	5.3
4.78	31.8	5.6	2.2	5.4
5.78	31.9	5.7	2.3	5.4
6.78	32.7	5.6	2.2	5.4
7.78	32.4	5.6	2.2	5.4
8.78	31.5	5.5	2.2	5.3
9.78	31.1	5.4	2.1	5.2
10.78	29.1	5.1	2.0	4.9
11.78	29.9	5.3	2.1	5.1
12.78	29.8	5.3	2.0	5.1
1.79	29.1	5.1	2.0	5.1
2.79	29.3	5.1	2.0	5.1
3.79	29.4	5.2	2.0	5.1
4.79	30.0	5.3	2.0	5.1
5.79	30.5	5.4	2.1	5.2
6.79	30.3	5.4	2.1	5.2
7.79	29.2	5.2	2.0	5.0
8.79	29.3	5.3	2.0	5.0
9.79	28.9	5.2	2.0	5.0

APPENDIX B
AUTO AND PARTIAL CORRELATION COEFFICIENTS
FOR FIRST DIFFERENCES IN THE FOUR COUNTRIES

Belgium

Time Lag	Auto Correlation Coefficients	Partial Correlation Coefficients
24	0.05	0.02
23	0.12 *	0.12 *
22	0.09 *	-0.02
21	0.11 *	0.05
20	0.23 **	0.07
19	0.12 *	0.10
18	-0.00	0.00
17	-0.05	-0.03
16	-0.06	-0.17 *
15	-0.02	0.04
14	-0.15 *	-0.14
13	-0.07	-0.01
12	0.06	-0.05
11	-0.04	-0.05
10	-0.02	-0.11 *
9	0.01	-0.02
8	0.06	-0.01
7	-0.03	0.22 **
6	-0.39 **	-0.35 **
5	-0.15 *	0.10
4	-0.10 *	-0.10
3	-0.01	-0.00
2	0.03	-0.06
1	0.30 **	0.30 **

*greater than one sigma
**greater than two sigma

Denmark

Time Lag	Auto Correlation Coefficients	Partial Correlation Coefficients
24	0.06	0.10
23	0.16 *	0.08
22	0.00	-0.03
21	0.15 *	0.10
20	0.24 *	0.12
19	0.08	0.09
18	0.05	0.02
17	-0.12	-0.15 *
16	-0.04	-0.07
15	0.00	-0.04
14	-0.17 *	-0.14 *
13	0.03	-0.01
12	0.01	-0.04
11	-0.07	-0.12 *
10	0.03	0.06
9	-0.14 *	-0.18 *
8	0.11	0.11
7	-0.07	-0.01
6	-0.28 **	-0.28 **
5	-0.04	-0.03
4	-0.03	-0.04
3	0.01	0.02
2	-0.02	-0.04
1	0.12	0.12 *

*greater than one sigma
**greater than two sigma

Netherlands

Time Lag	Auto Correlation Coefficients	Partial Correlation Coefficients
24	0.04	-0.00
23	0.04	0.06
22	-0.04	-0.05
21	0.14	0.12 *
20	0.20 *	0.15 *
19	-0.04	-0.02
18	0.03	0.01
17	0.00	-0.00
16	0.02	-0.08
15	-0.11	-0.15 *
14	0.02	0.02
13	-0.07	-0.03
12	-0.01	0.01
11	-0.06	-0.16 *
10	-0.01	-0.09
9	-0.04	0.01
8	0.03	0.03
7	0.07	0.08
6	-0.10	-0.12 *
5	-0.29 **	-0.29 **
4	0.10	0.10
3	-0.01	-0.01
2	0.01	0.01
1	-0.03	-0.03

*greater than one sigma
**greater than two sigma

Norway

Time Lag	Auto Correlation Coefficients	Partial Correlation Coefficients
24	0.09	0.11 *
23	0.17 *	0.02
22	0.11	0.08
21	0.10	0.07
20	0.16 *	0.17 *
19	0.09	0.01
18	0.02	0.12 *
17	-0.21 *	-0.26 **
16	-0.09	-0.03
15	-0.00	0.00
14	-0.00	0.03
13	-0.01	-0.07
12	0.05	-0.02
11	-0.02	-0.09
10	0.11	0.08
9	0.05	0.02
8	0.02	-0.01
7	-0.13	0.00
6	-0.33 **	-0.33 **
5	-0.06	-0.05
4	-0.04	-0.03
3	-0.04	-0.01
2	-0.05	-0.09
1	0.21 *	0.21 **

*greater than one sigma
**greater than two sigma

APPENDIX C
MODELS FOR THE FOUR COUNTRIES

The model for each country was of the form

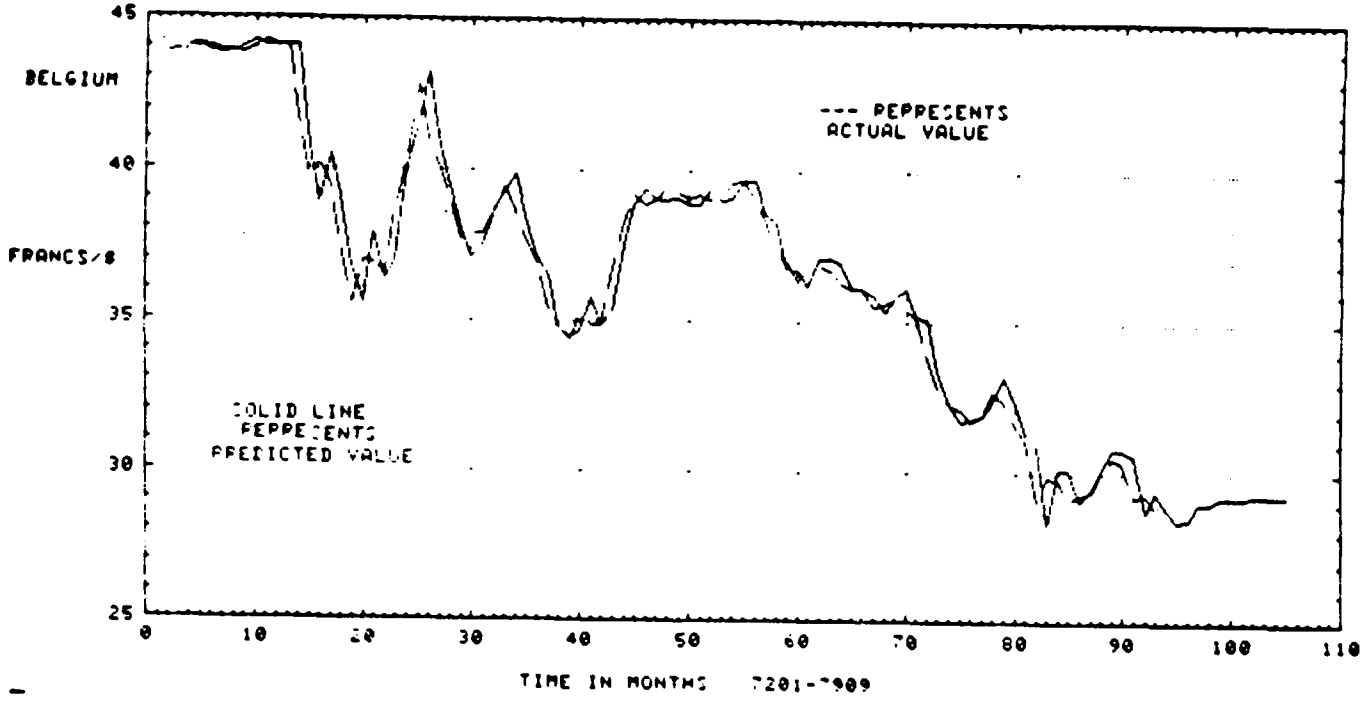
$$(1 - WB)Y_t = (1 - \theta_s^* B^s)\, e_t$$

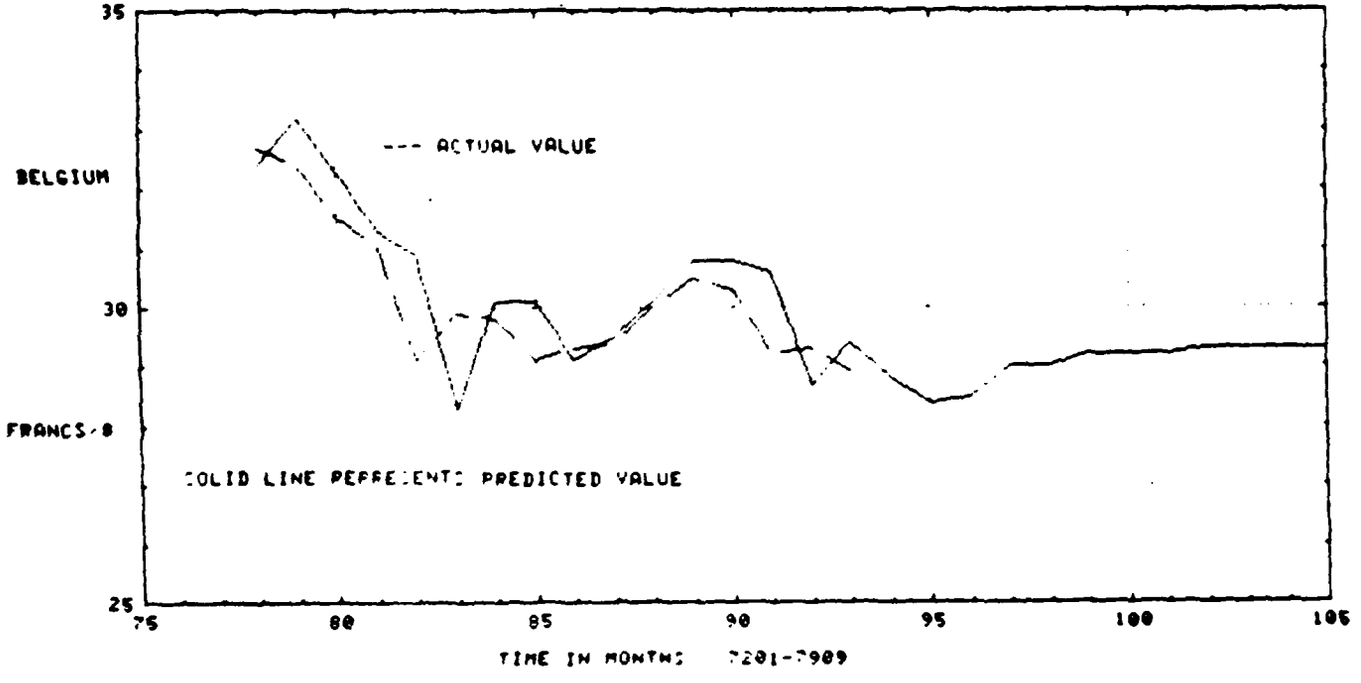
In all countries except the Netherlands, the seasonality used was six months. For the Netherlands, five months fit better. Y_t is the one month change in exchange rate.

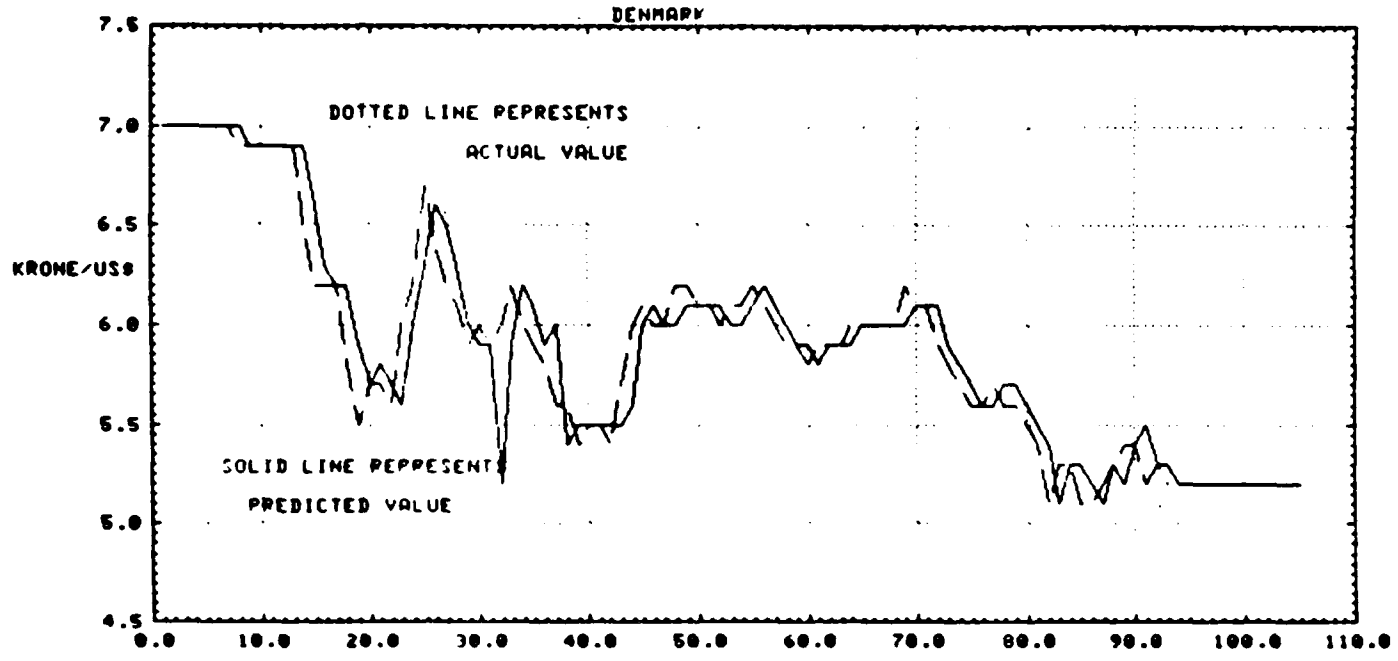
Coefficient	Belgium	Denmark	Netherlands	Norway
W	.371	.118	.020	.22
θ_s^*	.365	.259	.265	.29
s	6	6	5	6
Std Error	.104	.104	.104	.104
Chi Sqrd	12.43	18.25	17.59	18.91

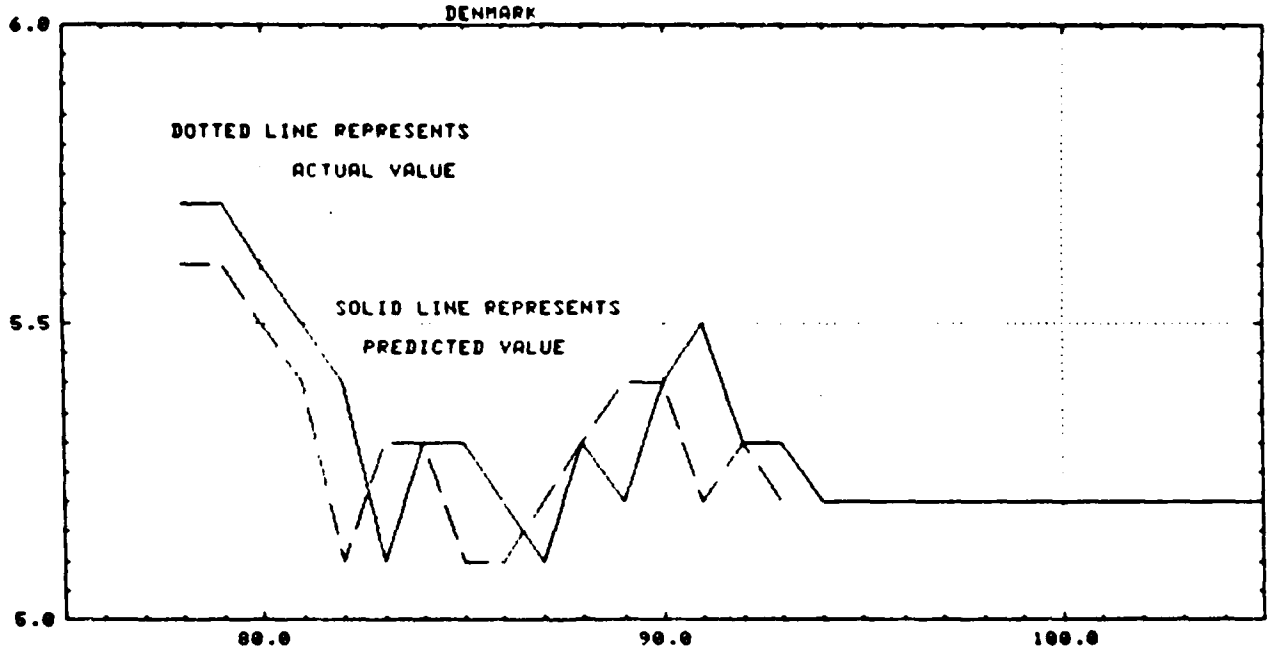
APPENDIX D

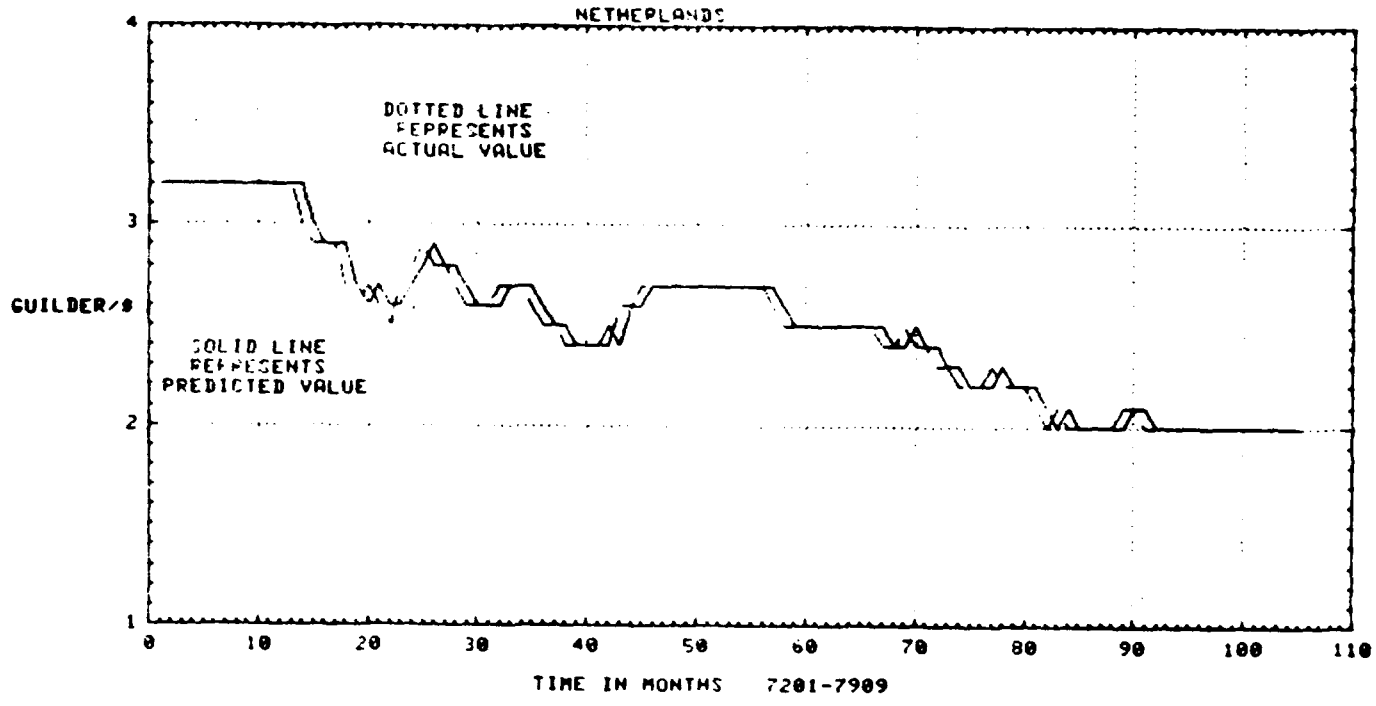
GRAPHS OF RESULTS

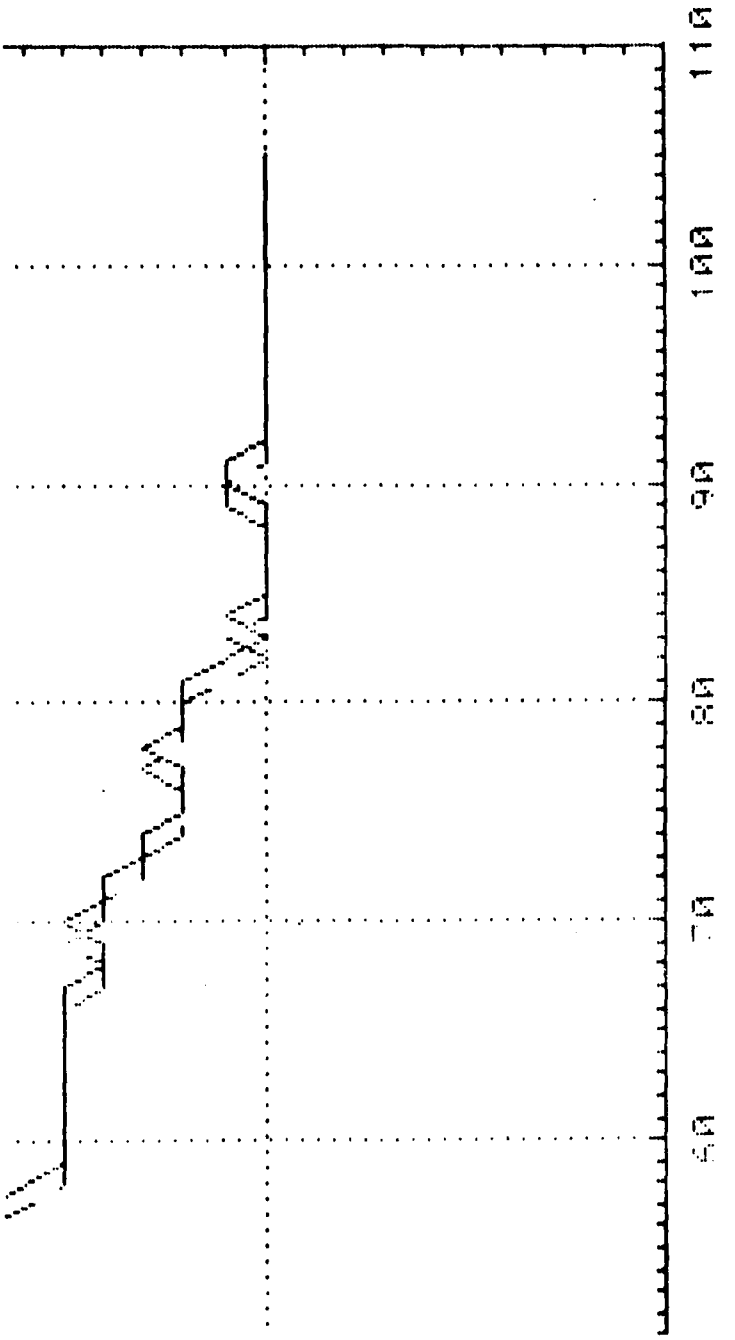

45
BELGIUM
40
FRANCS/$
35
30
25
--- REPRESENTS
ACTUAL VALUE
SOLID LINE
REPRESENTS
PREDICTED VALUE
0
10
20
30
40
50
60
70
80
90
100
110
TIME IN MONTHS 7201-7909

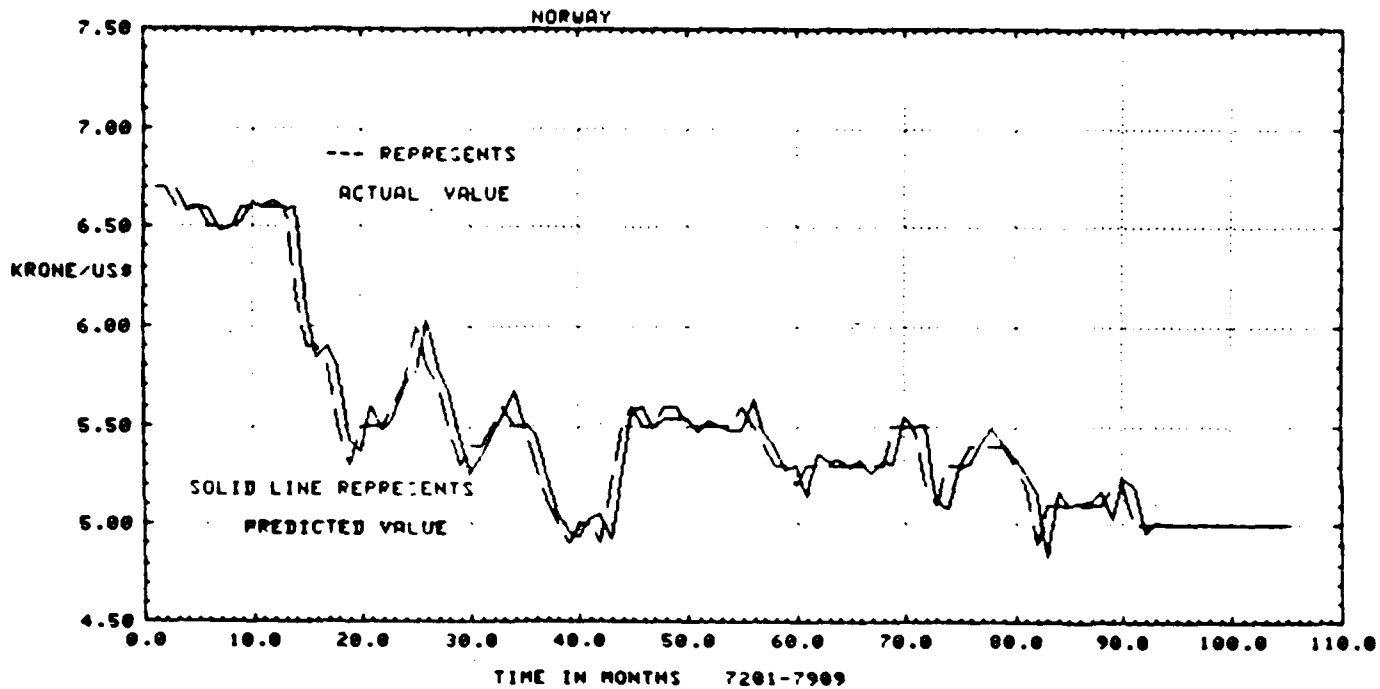

35
30
25
BELGIUM
FRANCS-B
--- ACTUAL VALUE
SOLID LINE REPRESENTS PREDICTED VALUE
75
80
85
90
95
100
105
TIME IN MONTHS 7201-7909

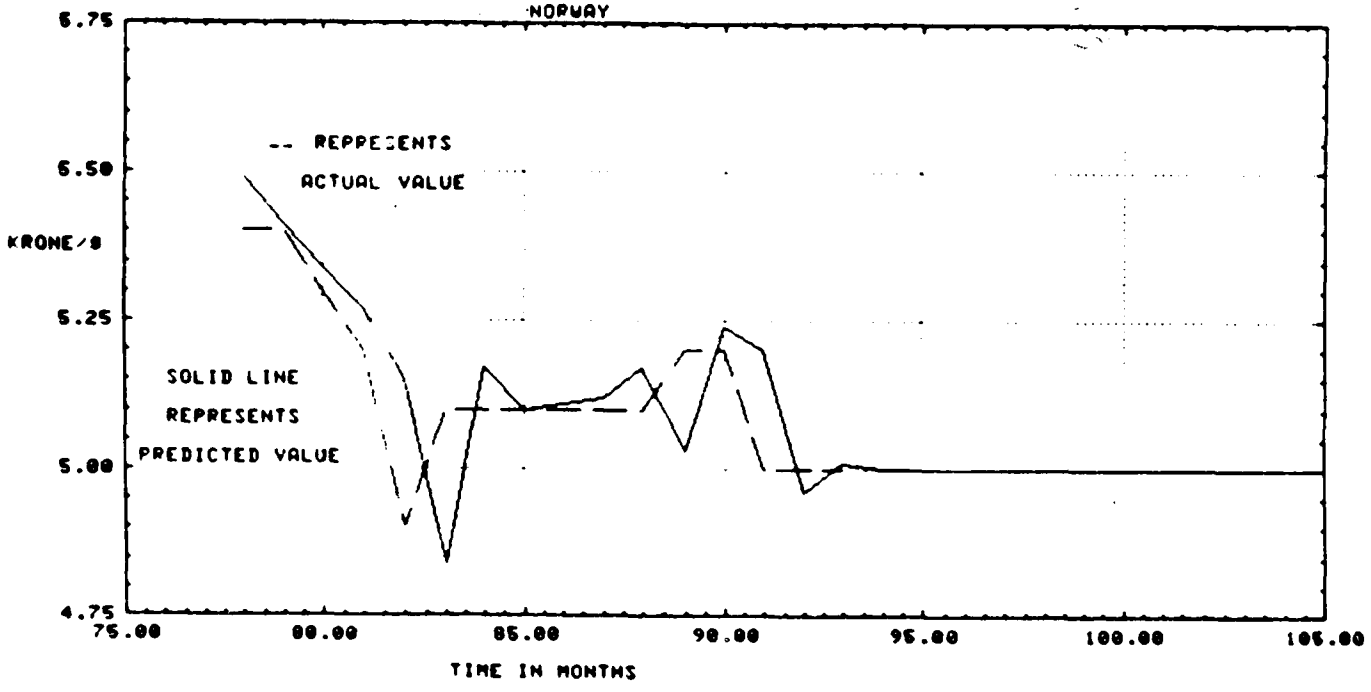

DENMARK
DOTTED LINE REPRESENTS
ACTUAL VALUE
SOLID LINE REPRESENTS
PREDICTED VALUE
KRONE/US$
7.5
7.0
6.5
6.0
5.5
5.0
4.5
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0


DENMARK
6.0
5.5
5.0
DOTTED LINE REPPRESENTS
ACTUAL VALUE
SOLID LINE REPRESENTS
PREDICTED VALUE
80.0
90.0
100.0


NETHERLANDS
DOTTED LINE
REPRESENTS
ACTUAL VALUE
SOLID LINE
REPRESENTS
PREDICTED VALUE
GUILDER/$
4
3
2
1
0
10
20
30
40
50
60
70
80
90
100
110
TIME IN MONTHS 7201-7909


110
100
90
80
70
60


NORWAY
7.50
7.00
6.50
6.00
5.50
5.00
4.50
KRONE/US$
--- REPRESENTS
ACTUAL VALUE
SOLID LINE REPRESENTS
PREDICTED VALUE
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
TIME IN MONTHS 7201-7909


NORWAY
6.75
6.50
6.25
6.00
5.75
KRONE/$
-- REPRESENTS
ACTUAL VALUE
SOLID LINE
REPRESENTS
PREDICTED VALUE
75.00
80.00
85.00
90.00
95.00
100.00
105.00
TIME IN MONTHS